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Hazardous Waste Engineering Research Laboratory Cincinnati OH 45268

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Project Summary

Handbook for Stabilization/ Solidification of Hazardous Waste

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In response to the growing interest in stabilization and solidification of hazardous wastes and contaminated soils and sediments, the Land Pollution Control Division of EPA's Hazardous Waste Engineering Research Laboratory has produced a technical Handbook on the subject. This Handbook provides details of the materials and equipment in common use and outlines methodologies for applying these techniques to hazardous waste problems. Among the subjects covered are waste and site characterization, laboratory testing and leaching protocols, bench and pilot scale testing, and full scale operations. Four stabilization/solidification scenarios are presented to illustrate advantages, disadvantages, and costs for different mixing techniques.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The terminology associated with stabilization/solidification technology is not rigidly defined and is often confusing. For this Handbook, stabilization refers to those techniques that reduce the hazard potential of a waste by converting the contaminants into their least soluble, mobile, or toxic form. The physical nature and handling characteristics of the waste are not necessarily changed by stabilization. Solidification refers to techniques that encapsulate the waste in a monolithic solid of high structural integrity. The encapsulation may be of fine waste particles (microencapsulation) or of a large block or container of wastes (macroencapsulation). Solidification does not necessarily involve chemical interaction between the waste and the solidifying reagents, but may involve mechanically binding the waste into the monolith. Contaminant migration is restricted by vastly decreasing the surface area exposed to leaching, or by isolating the waste within an impervious capsule.

Considerable impetus has been given to stabilization/solidification by both the Resource Conservation and Recovery Act (RCRA) and by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). These techniques are often the basis for delisting petitions under RCRA, and can be employed to satisfy the prohibition on the landfilling of liquids. Under CERCLA, solidification and encapsulation are specifically cited in the NCP (40 CFR 300) as methods to be considered during the feasibility study for remedying releases from contaminated soils and sediments.

Stabilization/Solidification Techniques

Most stabilization/solidification systems being marketed are proprietary processes involving the addition of absorbents and solidifying agents to a waste. Often the marketed process is changed to accommodate specific types of wastes. Since it is not possible to discuss completely all potential modifications to a process, discussions of most processes are related directly to generic process types. The exact degree of performance observed in a specific system may vary widely from its generic type, but the general characteristics of a process and its products can be discussed.

Waste stabilization/solidification systems that have potentially useful application in remedial action include:

- Sorption
- Lime-fly ash pozzolan processes
- Pozzolan-portland cement processes
- Thermoplastic microencapsulation
- Macroencapsulation

Other less common techniques include:

- Self-cementation
- Vitrification

Pretreatment systems, which overlap with stabilization and sorption processes, can be used to achieve a number of results that condition the waste to ensure better and more economical containment after the remaining materials have been stabilized and solidified. These include:

- Destruction of materials (such as acids or oxidizers) that can react with solidification reagents (lime or portland cement)
- Chemical binding of specific waste constituents to solid phases added to scavenge toxic materials from solution and hold them in solids
- Techniques for improving the scale on which waste processing can be done, for example bulking and homogenizing waste to allow a single solidification system to be used with modification on a large volume of waste.

Neutralization, oxidation or reduction, and chemical scavenging stabilize the waste, in that they bring the chemical waste into an inert or less soluble form. Dewatering, consolidation, and waste-to-waste blending are also useful pretreatment methods which reduce the waste volume or numbers of different waste forms requiring treatment.

Waste Characterization

A thorough physical and chemical characterization of a waste is essential to determining the most suitable stabilization/solidification method, as well as any special pretreatment or material handling methods that may be required. Physical characterization focuses mainly on transport, storage, and mixing considerations. Chemical characterization focuses mainly on interfering compounds, hazard assessment, and compatibility.

Tests performed to characterize the physical properties of a waste will vary with the specific wastes and the stabilization/solidification techniques proposed for them. The physical determinations most commonly employed for stabilization/solidification are:

- Moisture content
- Suspended solids content
- Bulk Density
- Grain size distribution
- Atterberg limits
- Cone index
- Unconfined compressive strength

The purposes of chemical characterization are to determine the hazards associated with waste handling, to determine if interfering materials are present, and to examine waste/waste and waste/process compatibilities. The hazard potential, used to develop worker health and safety plans and equipment requirements, may be determined by analysis for priority pollutants. Tests to determine the presence of compounds deleterious to the intended stabilization/solidification process may be used to identify necessary pretreatment measures. Compatibility testing is used to determine if wastes can be mixed into larger bulks for treatment, and to determine if the wastes are amenable to various stabilization/solidification techniques.

Process Selection

The first measure taken in determining the feasibility of a stabilization/solidification technique as a remedial alternative, is to complete a thorough characterization of the wastes, and to calculate their volume. From this a determination of the need to pretreat the wastes can be made. Flammable, corrosive, reactive, and infectious wastes are among those that should not be considered for solidification without some form of pretreatment. If more than one pretreatment measure is required, as may be the case with complex wastes, some method other than solidification may become more cost-effective.

Another use for the waste characterization is to assess the degree of hazard associated with handling the wastes. The equipment and time needed to protect workers and nearby residents while extremely hazardous wastes are being processed may become prohibitively expensive.

An additional process selection measure is to characterize the site where the solidified wastes will be disposed. Because all solidification techniques result in increased volumes for disposal, and transportation costs are significant, wastes are usually solidified at the site where they will be disposed. Consequently, wastes are either excavated and hauled to a suitable site or the existing site is made suitable through modifications. Many uncontrolled sites can be made suitable to accept solidified wastes through the installation of a liner, leachate collection system, or other engineering measure. As with the costs of pretreatment processes, the costs of site modifications for secure reburial may become limiting.

Another step in selecting a suitable process is to develop the specifications the solidified wastes must meet. Such specifications should include:

- Leachability
- Free liquid content
- Physical stability and strength
- Reactivity
- Ignitability
- Resistance to biodegradation
- Permeability

Standards for testing stabilized/solidified wastes have not yet been developed. A suggested program of specification and testing procedures are outlined in the Handbook.

Process Screening

Assuming that one or more stabilization/solidification processes are identified as feasible by the selection procedures, bench-scale or pilot scale studies can be used to choose and refine the most suitable technique. Areas of concern investigated by these studies include:

- Safe waste handling procedures
- Waste uniformity
- Mixing and pumping properties
- Processing parameters
- Process control procedures
- Volume increases

A large stabilization/solidification operation has the potential to present many safety concerns. Heat generation, volatilization, and dust propagation are among the potential hazards. Also, the rapid addition of a reactive pretreatment or solidification agent such as lime, could cause a flash fire by rapid volatilization of organic chemicals. Many solidification reactions are exothermic, and an evaluation of the heat transfer characteristics of the treatment system is essential. The effects of heat transfer on reaction rates as the system is scaled up must also be evaluated.

Waste uniformity, and the mixing and pumping qualities at various points within the treatment system should also be subject to study. Serious problems can be caused by rapid viscosity increases within the system and must be evaluated, along with performance evaluations of the pumps, mixers or other equipment to be used.

Process parameters, including mix ratios, mix and set times, and volume increases are among the most important results of bench or pilot-scale testing. Due to the heterogeneity of wastes and many common treatment materials, many of the process parameters will be determined by trial and error. Moisture content of wastes or treatment agents can show wide variability, and significantly alter mix ratios.

Process Operation

Full-scale operation of a solidification process requires detailed planning and cost comparisons. The first planning step involves the characterization, testing and process selection efforts described above. The second phase of planning involves the development of the operation plan, including equipment requirements, work sequence and scheduling, and cost estimation for the specific site. These are briefly discussed below.

Equipment requirements are largely determined by the type of mixing to be employed in the process. The four types of mixing commonly used are in-drum, in-situ, plant and area.

Project sequencing and scheduling are largely determined by the type of mixing technique employed. The first step generally involves preparation of the site and construction of any necessary facilities. These could include excavation of an inground mixing pit, or construction of a disposal site to receive the processed waste. This is often followed by any needed evaluation of the wastes including such things as drum integrity or phase separations. The actual processing of the wastes then takes place, along with the process control monitoring. This is followed by waste curing and final disposal. Variations to these sequences are likely, due to process and site-specific factors.

Cost estimations for a full-scale processing operation must take into account costs for:

- Treatment reagents
- Labor
- Materials
- Equipment
- Cleanup
- Overhead and profit

These will depend on the solidification technique employed, the amount of waste to be processed, and many other site-specific constraints.

The number of waste processing, handling, and mixing technologies is highly varied, as is the number of treatment reagent-waste formulations. Waste and site characteristics, and reagent cost and availability are the major factors which must be weighted in project planning to ascertain the most cost-efficient and reliable containment strategy.

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The complete report, entitled "Handbook for Stabilization/Solidification of Hazardous Waste," (Order No. PB 87-116 745/AS; Cost: $18.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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